Introduction

Global concerns

- Aside from War in Ukraine
- Climate change and its detrimental impact on environmental sustainability
- The imbalance caused by human activities, leading to increased CO2 emissions

Sub-Saharan Africa

- Economic growth with reliance energy industry
- Environmental degradation challenges

	GDP/Capita (2021)	CO2 Emissions (2021)	Main industries
Ghana	$2,363	0.75mt	Mining and Quarrying, Tourism, Agriculture
Nigeria	$2,065	0.6mt	Mining and Quarrying, Agriculture, Manufacturing, transportation and finance
South Africa	$7,055	7.34mt	Mining and Quarrying, Manufacturing, Finance and transport
World average		4.69mt	

SDG 7

- Modern energy services; increasing the share of global energy mix; energy efficiency
- International cooperation for clean energy research and technology
- Energy infrastructure and technology in developing countries

These goals have existed long before SDG

Related Literature

- Studies have not investigated the dynamism effect of market-induced factors on CO2 increase in sub-Saharan African
- Market-induced factors: Albiman, et al. (2015), Asongu (2018), Gasimili, et al. (2019), Guterres (2019), Niva, et al. (2020)
  - Evidenced relationships between CO2 emissions and non-renewables; financial development; energy resources; manufacturing
  - Aminu et al. (2023) provided insights on the environmental management aspect of these factors
- FDI inflow: Khan et al. (2023), Wang and Huang (2022)
  - FDI inflows lower CO2 emissions for countries
  - Choice of specific technologies can be determined by host countries
- Population, industrialisation and energy use: (Hamilton and Kelly, 2017)
  - Rise in CO2 emissions has been evidenced in sub-Saharan Africa countries due to high population, economic growth, and related factors

Related Literature

- Causality of factors: Soytas and Sari (2017)
  - examined the relationship between energy consumption, economic growth and CO2 in Turkey
  - Employed granger causality approach in a multivariate VAR framework, discovered that CO2 granger cause energy consumption, but no reverse causation
  - Chontanawat, et al. (2016) did similar on India, with data from 1971 to 2006
- Limitations Granger causality: issues related to statistical power and size properties (Zapata and Rambaldi, 1997; Amiri and Ventelou, 2012)
- Granger causality's limitations includes:
  - inability to determine causality direction; failure to account for reverse causality
  - potential for spurious correlations; assumption of linear relationships
  - susceptibility to OVB; sensitivity to lag selection; dependence on sample size and data quality
- Bowden and Payne (2009) worked on the causality between energy consumption and economic growth in Greece, employing Toda and Yamamoto (1995) causality test
  - Revealed that there is a unidirectional causal relationship between energy consumption and GDP; concludes that energy consumption affects economic growth

Direction of the Study

- The purpose of this study is to investigate the relationship between market-induced factors and the dynamism in CO_2 emissions in three selected sub-Saharan African countries

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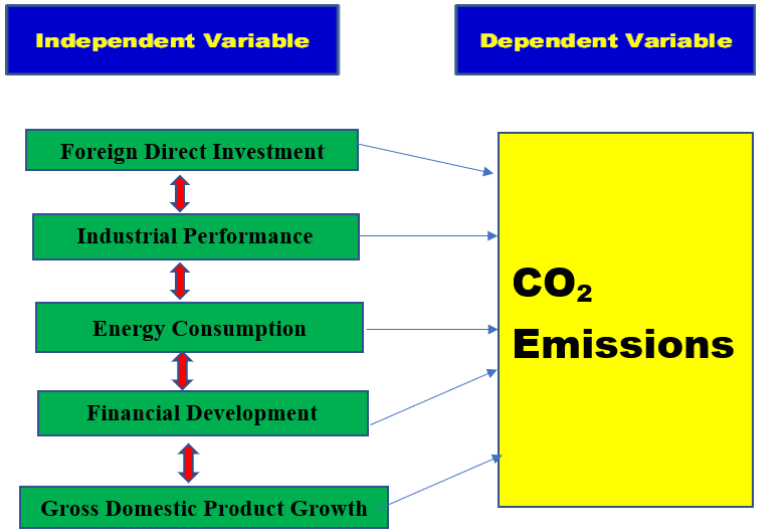
Method: Toda and Yamamoto (1995)

- T-Y estimation model tests for long-run causality is employed
- To determine the causal relationship between per capita CO2 emissions and economic growth, energy use, industrial growth and the financing aspect
  - allows for testing causality even when the variables of interest are integrated of different orders, such as having some variables that are integrated of order 1—I(1), and others that are integrated of order 0—I(0)
  - Addresses the limitations of Granger Causality tests
- Test involves estimating a vector autoregressive (VAR) model in levels, a technique that reduces the potential risks associated with erroneous conclusions
  - Performed through ordinary least squares (OLS) regression

Data and Model



- Develops the framework for the inter-connectedness between the dependent variable and independent variables
- Employs quarterly time series data for Ghana, Nigeria, and South Africa from 1990 to 2021
  - From the World Bank's World Development Indicators (WDI) and Energy Information Administration (EIA)
- Estimating the following VAR ($k + d_{max}$) model:

$$CO2_t = \propto + \beta_1 ENG_t + \beta_2 FDI_t + \beta_3 FD_t + \beta_4 IND_t + \beta_5 GDPg_t + \varepsilon_t$$

  - The test then examines the significance of the coefficients associated with the lagged values of the variables to determine if there is evidence of causal relationships

Variables	Description	Definition	Sources
CO_2	DV	Environmental quality measured by Carbon dioxide (CO_2) emissions per capita (metric tons per capita)	WDI
FDI	IV	Foreign Direct Investment, net inflows (% of GDP)	WDI
IND	IV	Industry (including construction), value added (% of GDP)	WDI
FD	IV	Financial development is proxy by domestic credit by financial sector (% of GDP)	WDI
ENG	IV	Fossil energy consumption measured by Petroleum and other liquid consumption (% of total)	EIA
GDPg	IV	Economic growth measured by Gross domestic product growth rate	WDI

Summary of Results

- ADF Unit root test: found variables are integrated of order 1 for all the countries Nigeria, Ghana and South Africa
- VAR lag order selection criteria show the optimal lag preference for Nigeria (6), Ghana (8) and South Africa (6)
  - A significant correlation between factors and CO2 emissions across all countries with VAR
- Nigeria: FD, IP and GDP growth causes CO2 emissions
  - 38.2% the land-use change and forestry sector; 32.6% energy; 14% waste; 13% others; 2.1% industrial processes sector
- Ghana: FOS and GDP Growth causes CO2 emissions
  - Recent explorations
- South Africa: No causality
  - Coal is South Africa's dominant energy source. 77% of South Africa's energy needs are provided by coal

Causality Test: Nigeria

NULL HYPOTHESIS	CHI-SQUARE	P-VALUE	REMARK
CO2 Emission does not granger cause FD	2.37	0.88	No causality
FD does not granger cause CO2 Emission	17.6	0.00	Causality
CO2 Emission does not granger cause IP	18.7	0.00	Causality
IP does not granger cause CO2 Emission	29.4	0.00	Causality
CO2 Emission does not granger cause GDPg	11.6	0.00	Causality
GDPg does not granger cause CO2 Emission	20.6	0.00	Causality
CO2 Emission does not granger cause FOS	1.88	0.92	No causality
FOS does not granger cause CO2 Emission	12.5	0.05	Causality
CO2 Emission does not granger cause FDI	40.3	0.00	Causality
FDI does not granger cause CO2 Emission	2.85	0.82	No causality

NIGERIA

Ghana & South Africa

	Null Hypothesis	Chi-square	P-Value	Remark
GHANA	CO2 Emission does not granger cause FD	5.62	0.68	No causality
	FD does not granger cause CO2 Emission	3.62	0.69	
	CO2 Emission does not granger cause IP	14.9	0.05	Causality
	IP does not granger cause CO2 Emission	4.44	0.81	No Causality
	CO2 Emission does not granger cause GDPg	10.6	0.22	No causality
	GDPg does not granger cause CO2 Emission	17.4	0.02	Causality
	CO2 Emission does not granger cause FOS	7.34	0.49	No causality
	FOS does not granger cause CO2 Emission	78.5	0.00	Causality
	CO2 Emission does not granger cause FDI	5.52	0.70	No causality
	FDI does not granger cause CO2 Emission	3.62	0.88	
South Africa	CO2 Emission does not granger cause FD	1.20	0.97	No causality
	FD does not granger cause CO2 Emission	3.83	0.69	
	CO2 Emission does not granger cause IP	2.22	0.87	No causality
	IP does not granger cause CO2 Emission	0.91	0.98	
	CO2 Emission does not granger cause GDPg	4.51	0.60	No causality
	GDPg does not granger cause CO2 Emission	0.43	0.99	
	CO2 Emission does not granger cause FOS	6.26	0.48	No causality
	FOS does not granger cause CO2 Emission	4.22	0.64	
	CO2 Emission does not granger cause FDI	5.52	0.48	No causality
	FDI does not granger cause CO2 Emission	6.22	0.29	

Conclusion

- The Toda-Yamamoto estimation model was used to analyse the relationship between CO_2 emissions and various exogenous variables in Nigeria, Ghana, and South Africa
- **South Africa**: found that the country's financial sector development has a dominant role in determining economic interactions and activities, with profound effects on the environmental quality
- The findings suggest
  - Economic Structure
    Energy Mix
    Policy Differences
    Technological Advancements
- Policymakers in SSA should prioritise the implementation of measures and the SDG 7
  - More cooperation
  - Policies that promote sustainable economic growth and development
  - Mitigating the impact on the environment

Question?

Email: naminu@cardiffmet.ac.uk

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